Three-phase PWM

UG0655 User Guide





Table of Contents

Introduction	3
Inverter Bridge for AC Motors	
Generating Center Aligned PWM	4
Dead Time and Delay time	5
Hardware Implementation	6
Inputs and Outputs	7
Configuration Parameters	7
Resource Utilization	8
List of Changes	9
Product Support	10
Customer Service	
Customer Technical Support Center	
Technical Support	
Website	
Contacting the Customer Technical Support Center	
ITAR Technical Support	11



Introduction

The three-phase PWM generates carrier based center aligned PWM to trigger the switches of a three-phase inverter. The module also introduces a configurable dead time to avoid dead short circuits. A delay time can be introduced to synchronize multiple three-phase PWM block instantiations for multi-axis or for harmonic cancellation in case of multi-level inverters.

Inverter Bridge for AC Motors

The three-phase inverter is the core of any AC motor drive. PWM pulses generated by the three-phase PWM drive the inverter bridge. This inverter bridge is as shown in Figure 1.



Figure 1. Three-phase Inverter Bridge

In Figure 1, a three-phase two level inverter consists of three power electronic switches (Transistors), two in each leg for each phase of motor winding. The switches in each leg are driven by complementary pulses to switch the phase voltage between positive and negative DC voltage. The DC voltage passes through the transistor switches to the load when at least one of the three-phase pulses is "active". Dead time is introduced between these high and low pulses of a phase or channel to allow the transistor to turn off completely, so that the DC source does not get shorted during operation.



Generating Center Aligned PWM

In center aligned PWM, the PWM counter goes from a down-count to an up-count to down-count again, and so on. Figure 2 represents the operation of center aligned PWM. The PWM counter keeps running as long as the module is not in reset state, even when the PWM module is not enabled.



Figure 2. Center Aligned PWM



Dead Time and Delay time

A time delay is introduced between turning OFF one of the transistors of a leg of an inverter to turning ON the other transistor to ensure that a dead short circuit does not occur. This is called dead time. This is as shown in Figure 3.



Figure 3. Dead Time Insertion

When multiple PWM blocks are present in a single system, some harmonics can be eliminated by phase shifting the PWM carrier wave. This time delay – referred to as delay time is represented in Figure 4. This time delay is accounted for by the delay in generating carrier waves after reset.



Figure 4. Effect of Delay Time



Hardware Implementation



Figure 5. System-level Block Diagram of Three-phase PWM



Inputs and Outputs

Table 1 shows the input and output ports of three-phase PWM.

Table 1. In	puts and Output	ts of three-phas	e PWM

Signal Name	Direction	Description
reset_i	Input	Asynchronous active low reset signal
sys_clk_i	Input	System Clock
en_pwm_i	Input	Asynchronous enables:
		When 0, PWM outputs are driven to "0"
		When 1, PWM outputs are generated
va_i	Input	Phase A duty cycle with respect to pwm_period
vb_i	Input	Phase B duty cycle with respect to pwm_period
vc_i	Input	Phase C duty cycle with respect to pwm_period
pwm_period_i	Input	Time period of PWM in number of system clock time
dead_time_i	Input	Dead time
delay_time_i	Input	Delay time
midmatch_o	Output	Period mid-match interrupt
PWM_AH_O	Output	Channel A PWM for high side switch
PWM_AL_O	Output	Channel A PWM for low side switch
PWM_BH_O	Output	Channel B PWM for high side switch
PWM_BL_O	Output	Channel B PWM for low side switch
PWM_CH_O	Output	Channel C PWM for high side switch
PWM_CL_O	Output	Channel C PWM for low side switch

Configuration Parameters

Table 2 shows the description of the configuration parameters used in the hardware implementation of three-phase PWM. These are generic parameters and can be varied as per the requirement of the application.

Table 2. Configuration Parameters

Signal Name	Description
g_STD_IO_WIDTH	Defines the width of the input and output signals



Resource Utilization

Three-phase PWM is implemented on the SmartFusion[®]2 system-on-chip (SoC) field programmable gate array (FPGA) and IGLOO[®]2 devices. Table 3 shows the resource utilization report after synthesis with STD_IO_WIDTH value equal to 18.

· · · · · · · · · · · · · · · · · · ·		
Cell Usage	Count	
SLE (Sequential)	23	
Combinational Logic	194	
MACC	0	
RAM1Kx18	0	
RAM64x18	0	

Table 3. Resource Utilization Report of Three-phase PWM



List of Changes

The following table shows important changes made in this document for each revision.

Date and Revision	Change	Page
Revision 1 (October 2015)	Initial release.	N/A



Product Support

Microsemi SoC Products Group backs its products with various support services, including Customer Service, Customer Technical Support Center, a website, electronic mail, and worldwide sales offices. This appendix contains information about contacting Microsemi SoC Products Group and using these support services.

Customer Service

Contact Customer Service for non-technical product support, such as product pricing, product upgrades, update information, order status, and authorization.

From North America, call **800.262.1060** From the rest of the world, call **650.318.4460** Fax, from anywhere in the world **650. 318.8044**

Customer Technical Support Center

Microsemi SoC Products Group staffs its Customer Technical Support Center with highly skilled engineers who can help answer your hardware, software, and design questions about Microsemi SoC Products. The Customer Technical Support Center spends a great deal of time creating application notes, answers to common design cycle questions, documentation of known issues and various FAQs. So, before you contact us, please visit our online resources. It is very likely we have already answered your questions.

Technical Support

For Microsemi SoC Products Support, visit http://www.microsemi.com/products/fpga-soc/design-support/fpga-soc-support.

Website

You can browse a variety of technical and non-technical information on the Microsemi SoC Products Group home page, at http://www.microsemi.com/products/fpga-soc/fpga-and-soc.

Contacting the Customer Technical Support Center

Highly skilled engineers staff the Technical Support Center. The Technical Support Center can be contacted by email or through the Microsemi SoC Products Group website.

Email

You can communicate your technical questions to our email address and receive answers back by email, fax, or phone. Also, if you have design problems, you can email your design files to receive assistance. We constantly monitor the email account throughout the day. When sending your request to us, please be sure to include your full name, company name, and your contact information for efficient processing of your request.

The technical support email address is soc_tech@microsemi.com.

My Cases

Microsemi SoC Products Group customers may submit and track technical cases online by going to My Cases.



Outside the U.S.

Customers needing assistance outside the US time zones can either contact technical support via email (soc_tech@microsemi.com) or contact a local sales office. Visit About Us for sales office listings and corporate contacts.

ITAR Technical Support

For technical support on RH and RT FPGAs that are regulated by International Traffic in Arms Regulations (ITAR), contact us via soc_tech@microsemi.com. Alternatively, within My Cases, select **Yes** in the ITAR drop-down list. For a complete list of ITAR-regulated Microsemi FPGAs, visit the ITAR web page.



Microsemi Corporate Headquarters One Enterprise, Aliso Viejo, CA 92656 USA

Within the USA: +1 (800) 713-4113 Outside the USA: +1 (949) 380-6100 Sales: +1 (949) 380-6136 Fax: +1 (949) 215-4996

E-mail: sales.support@microsemi.com

© 2015 Microsemi Corporation. All rights reserved. Microsemi and the Microsemi logo are trademarks of Microsemi Corporation. All other trademarks and service marks are the property of their respective owners.

Microsemi Corporation (Nasdaq: MSCC) offers a comprehensive portfolio of semiconductor and system solutions for communications, defense & security, aerospace and industrial markets. Products include high-performance and radiation-hardened analog mixed-signal integrated circuits, FPGAs, SoCs and ASICs; power management products; timing and synchronization devices and precise time solutions, setting the world's standard for time; voice processing devices; RF solutions; discrete components; security technologies and scalable anti-tamper products; Ethernet solutions; Power-over-Ethernet ICs and midspans; as well as custom design capabilities and services. Microsemi is headquartered in Aliso Viejo, Calif., and has approximately 3,600 employees globally. Learn more at **www.microsemi.com**.

Microsemi makes no warranty, representation, or guarantee regarding the information contained herein or the suitability of its products and services for any particular purpose, nor does Microsemi assume any liability whatsoever arising out of the application or use of any product or circuit. The products sold hereunder and any other products sold by Microsemi have been subject to limited testing and should not be used in conjunction with mission-critical equipment or applications. Any performance specifications are believed to be reliable but are not verified, and Buyer must conduct and complete all performance and other testing of the products, alone and together with, or installed in, any end-products. Buyer shall not rely on any data and performance specifications or parameters provided by Microsemi. It is the Buyer's responsibility to independently determine suitability of any products and to test and verify the same. The information provided by Microsemi hereunder is provided "as is, where is" and with all faults, and the entire risk associated with such information is entirely with the Buyer. Microsemi does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other IP rights, whether with regard to such information itself or anything described by such information. Information provided in this document is proprietary to Microsemi, and Microsemi reserves the right to make any changes to the information in this document or to any products and services at any time without notice.